D2M2 Dredge Material Disposal Management Model & Tools for Sustainable Sediment Management

ERDC
Engineer Research and Development Center

Topics:

1. **D2M2 Dredging Optimization**
2. **Life-Cycle Assessment for Sediment Disposal**
3. **Structured Stakeholder Interaction, LIS DMMP**

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RSM & EWN Workshop, Portland, OR

1. D2M2: Geospatial Optimization of Complex Sediment Management Decisions

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Background

- The Corps of Engineers' maintenance of navigable federal waterways is increasingly complex.
- We spend nearly $2 billion on dredging, for over 2.2 billion tones of commercial shipping & public access.
- Optimization can help save costs, improve benefits, include stakeholder views, and increase efficiency.

Background

- Multifaceted planning problem:
  - Multiple stakeholders with opposing interests.
  - Public concern over environmental exposure.
  - High complexity in number of site variables.
  - Desire to use material beneficially for limited cost.

Multi-Criteria Decision Analysis

- *Multi-Criteria Decision Analysis* can be applied to structure and evaluate complex dredging problems.
- Enumerates fixed project alternatives being considered.
- Elicits & weights decision criteria.
- Scores alternatives in relation to each criterion.

- Aggregates across criteria for a composite metric for comparison.

MCDA Process

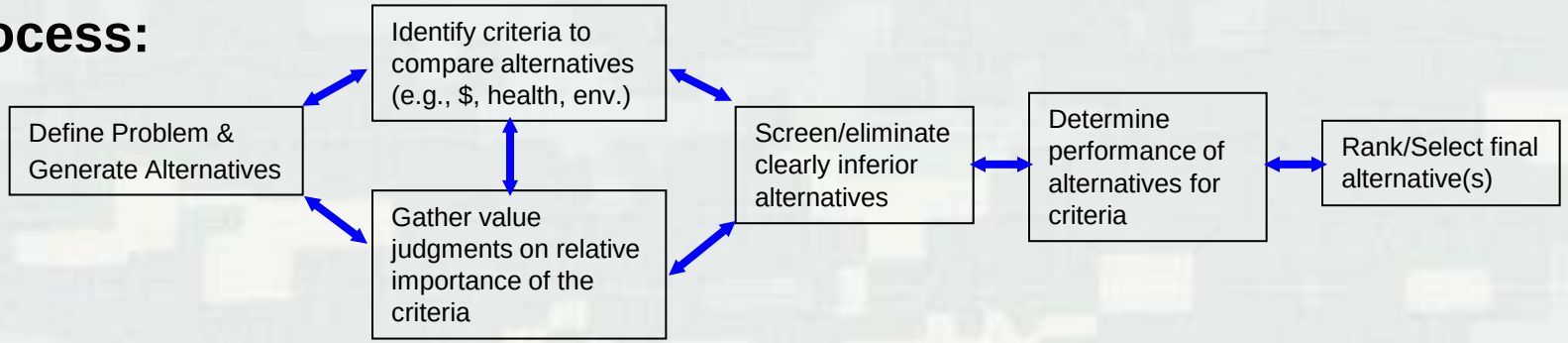
People:

Policy Decision Maker(s)

Scientists and Engineers

Stakeholders (Public, Business, Interest groups)

Process:



Tools:

Environmental Assessment / Modeling (Risk / Ecological/Environmental Assessment and Simulation Models)

Decision Analysis (Group Decision Making Techniques / Decision Methodologies and Software)

MCDA Example

For Example:

- Criteria: Economics, Environmental Exposure, Social
- Alternatives:
  - 1000K cuy to Ocean
  - 500K cuy to Ocean + 500 cuy Upland
  - 1000K cuy Upland
- Evaluate three alts on each criterion & choose the one that is best overall.

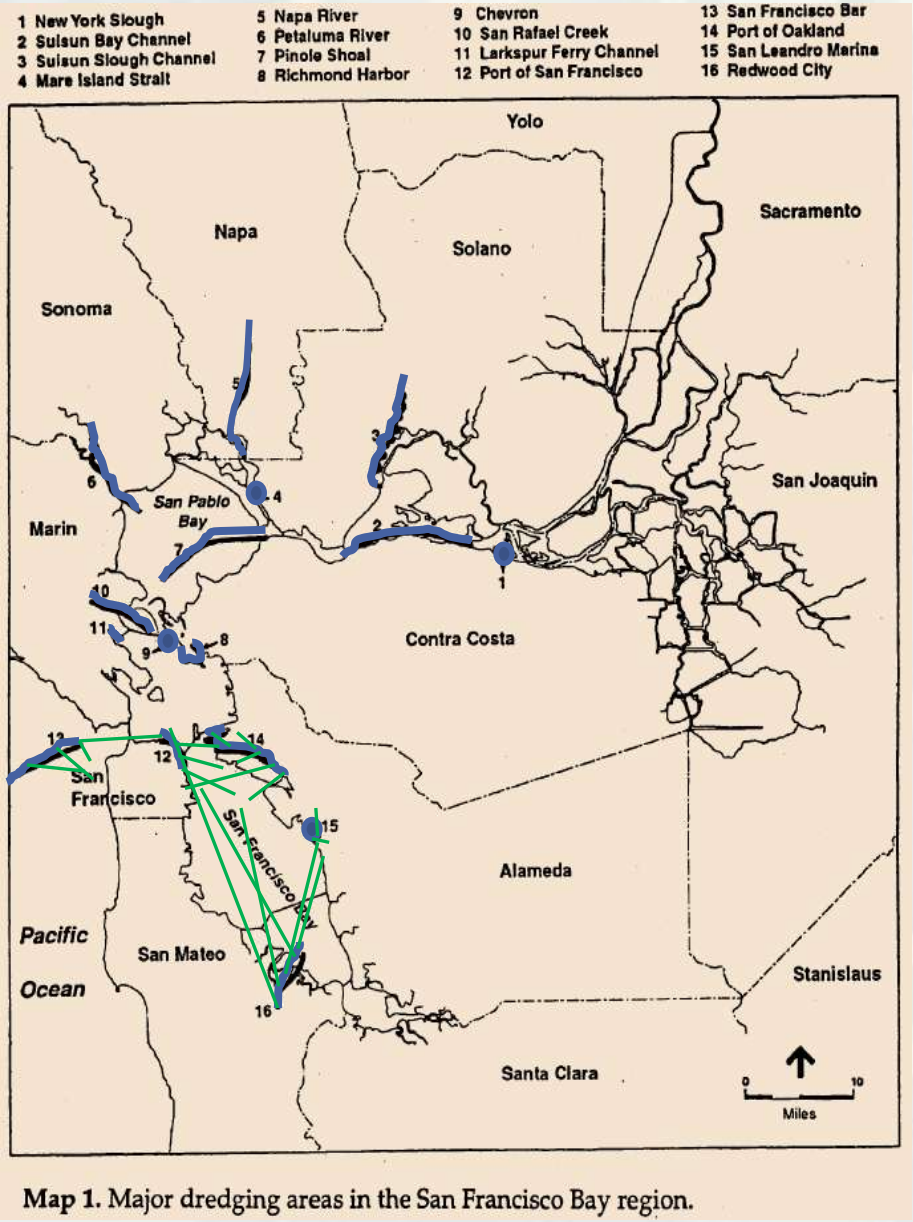
Multiobjective Optimization

- *Multiobjective Optimization:*
- Similar, but instead of specifying fixed alternatives, levels are automatically compared and selected to achieve the highest score.
- *Example*: _% Ocean + _% Upland placement = 100%.

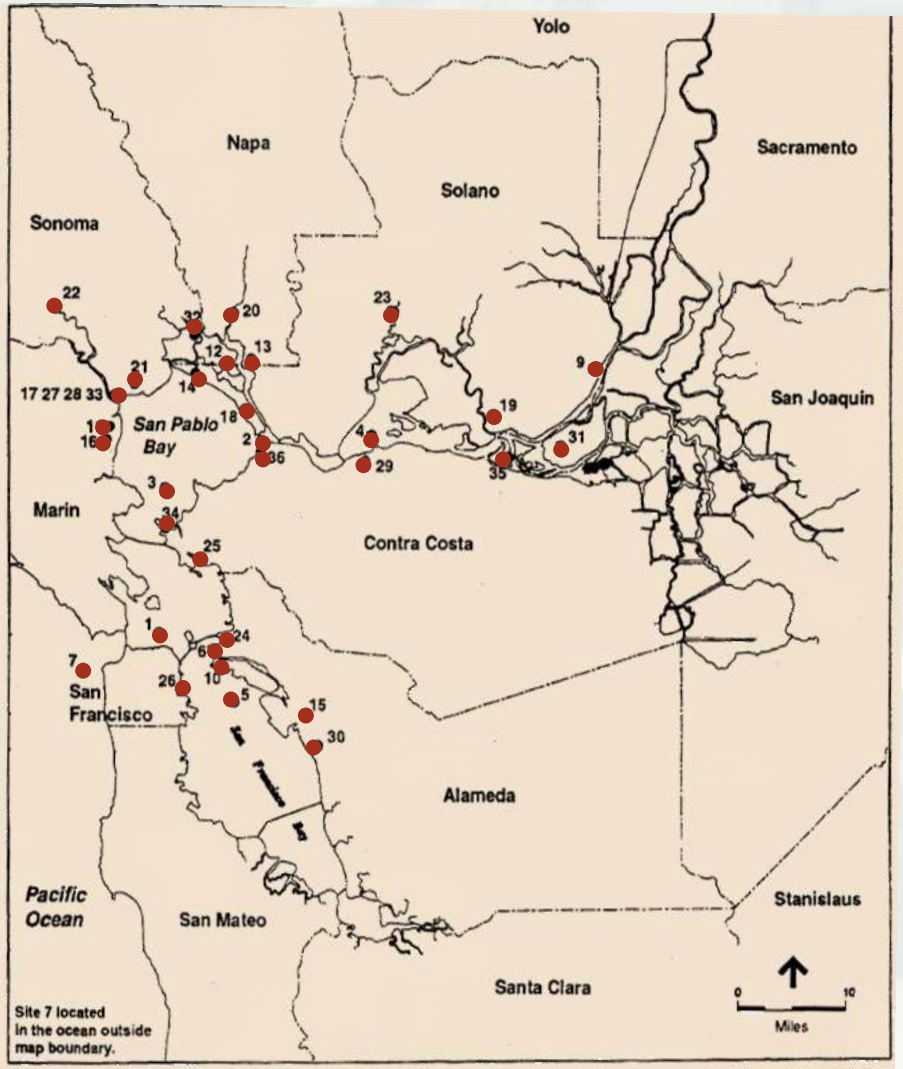
- User-defined constraints & relationships between variables drive the process.

Geospatial Multiobjective Optimization

- *Geospatial Multiobjective Optimization – D2M2:*
- Similar, but constraints and variable relationships are dynamically drawn from the geospatial environment.
- *Example*: _% Ocean + _% Upland placement = 100%, based on cost and environmental impact of path length.
- Can use automated GIS tools to find best paths and volumes, given simple landform-score relationships.



Map 1. Major dredging areas in the San Francisco Bay region.

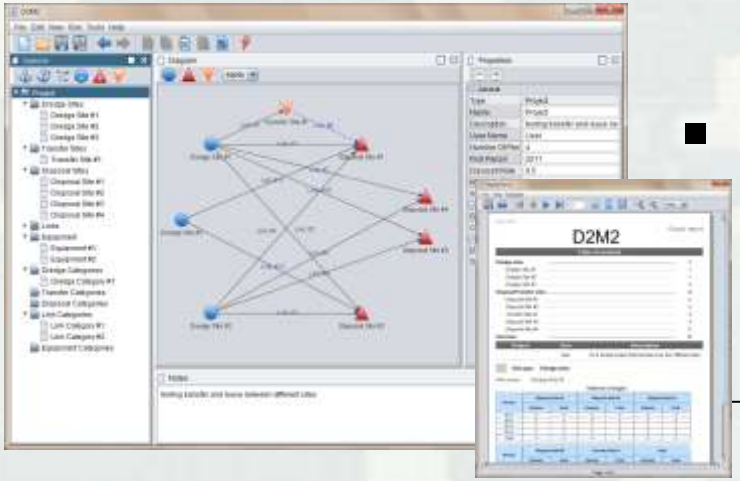


Map 2. Existing and potential disposal sites.

Source: Dredging and Disposal Road Map, San Francisco Bay Conservation and Development Commission, June 1999, http://www.spn.usace.army.mil/conops/ddrm2.pdf

D2M2 History

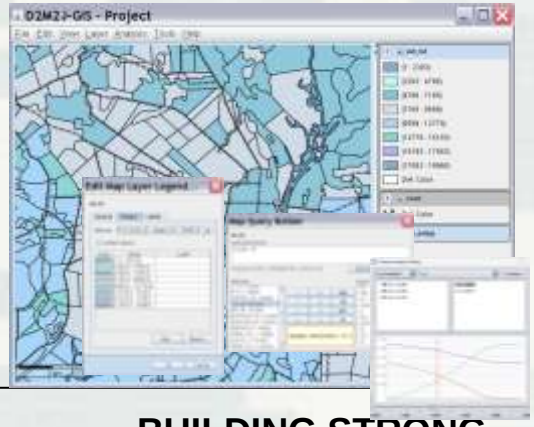
- Dredging planning optimization tool originally developed by USACE in the 1980s.
- Mixture of Fortran, C++, Visual Basic, and other languages.
- Saw limited use in San Francisco & other districts.



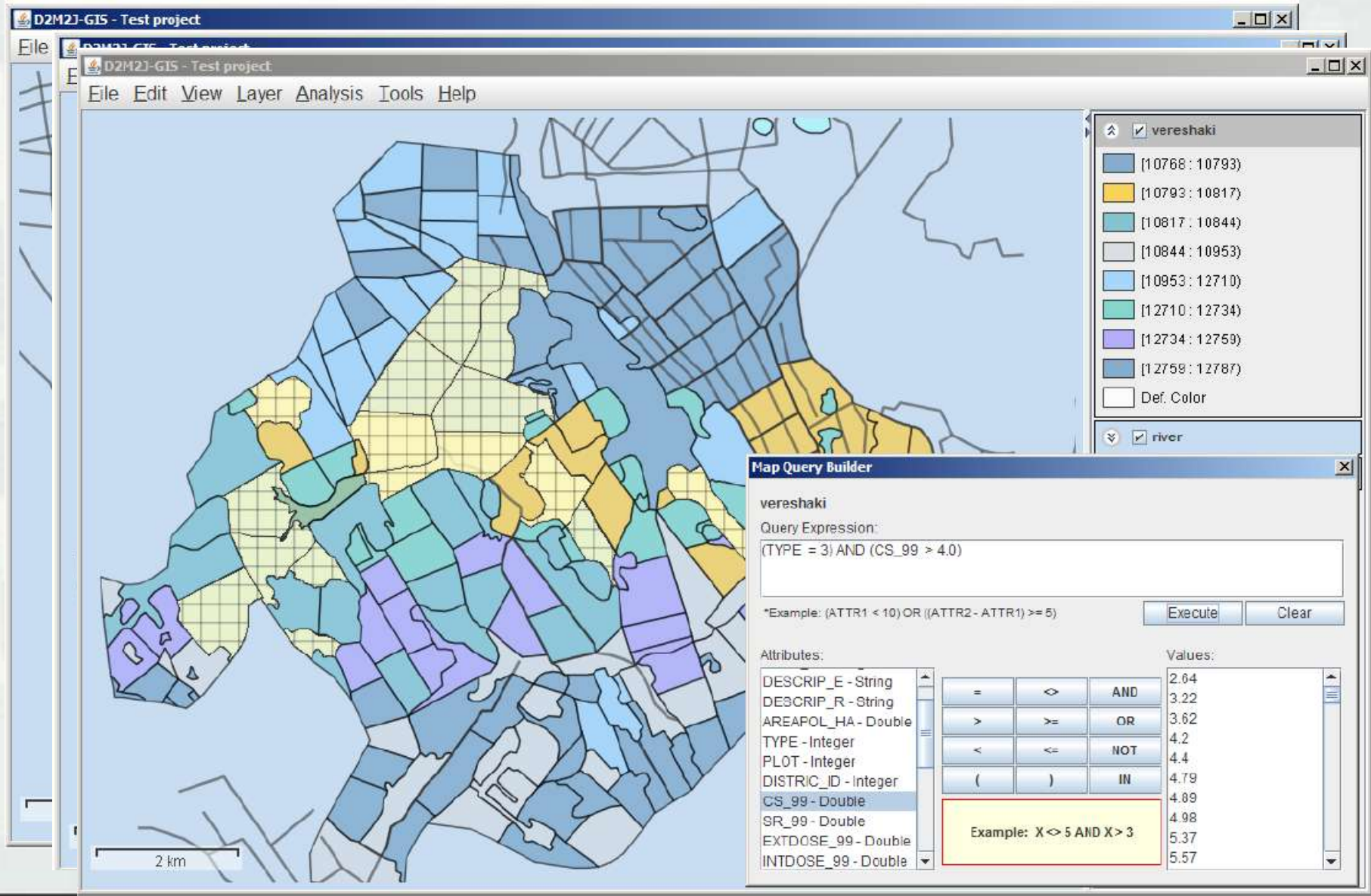
- Software lacked GIS, advanced MCDA, & a user-friendly interface.

New D2M2 Software

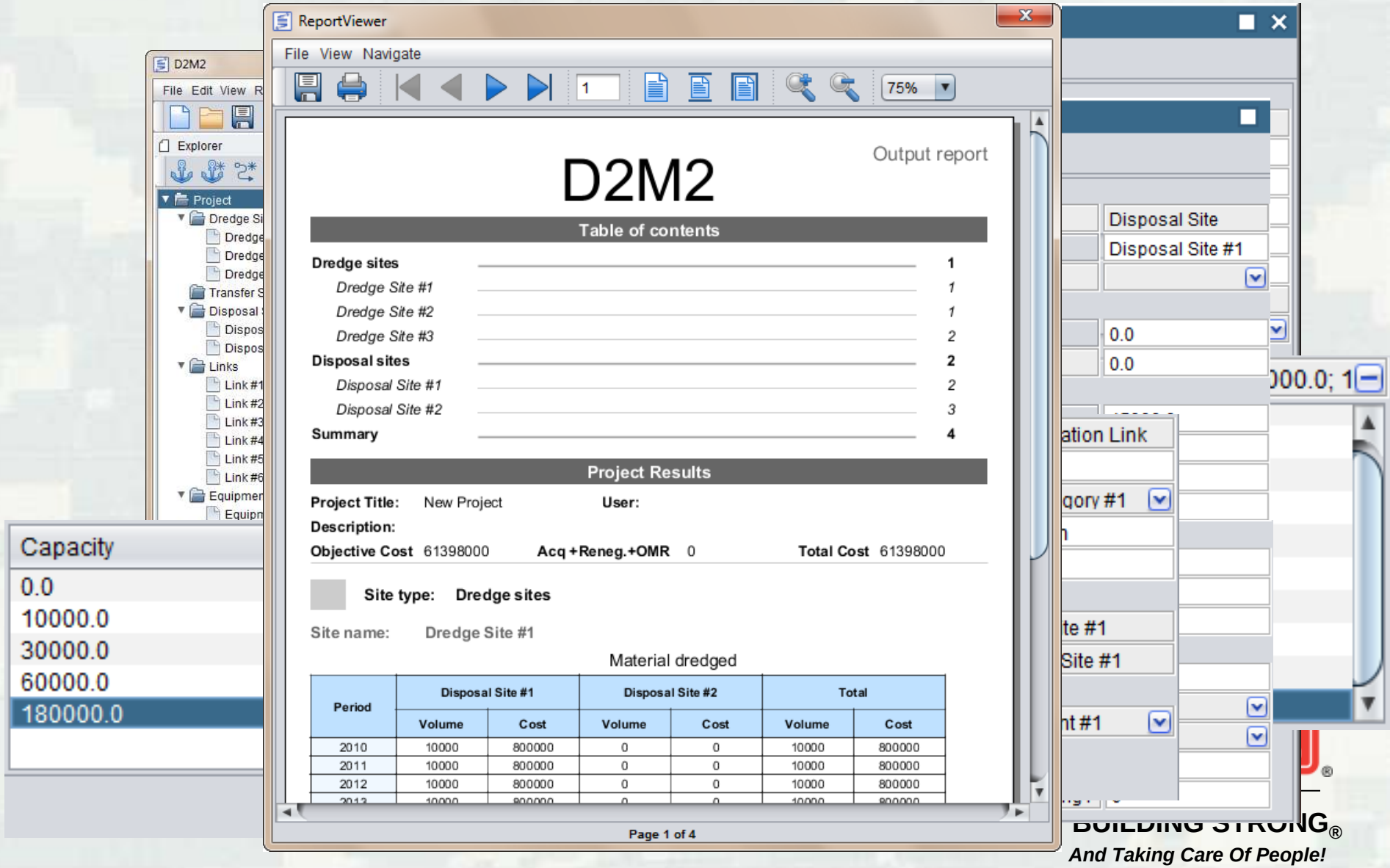
- Currently finishing FY11-12 D2M2 redevelopment.
- Incorporating full suite of MCDA techniques.
- Pushing the boundaries of Geospatial multiobjective optimization, considering millions of planning alts.
- All code open source, platform independent, in Java.
- Integrated stakeholder/DM judgment.
- First application underway in SF Bay.



D2M2 Screenshots – GIS Module



D2M2 Screenshots – Optimization Module



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D2M2 Screenshots – MCDA Module

Conclusions and Next Steps

- Automatically explores thousands of planning alts.
- Enables explicit consideration of multiple objectives (e.g., economic, environmental, social).
- Shows opportunity cost/benefit of BU & EWN solutions.
- Adds transparency, rigor, and flexibility to analysis.
- Can easily see trade-offs based on stakeholder views.
- Enables easy scenario and “what if” analysis.

- Next steps: Building a user community & case studies.
- Please let me know if you are interested!

Thank you

Link to Download

- http://dl.dropbox.com/u/33445846/install.jar
  - For an installer that wraps the D2M2 software
- http://dl.dropbox.com/u/33445846/d2m2_portable.zip
  - For a portable “zipped” version that doesn’t require installation.

Disclaimer: D2M2 is draft software, it is still undergoing final testing and debugging, please email us for latest versions before using on projects.

2. Life Cycle Assessment of Dredged-Sediment Management

Engineer Research and Development Center

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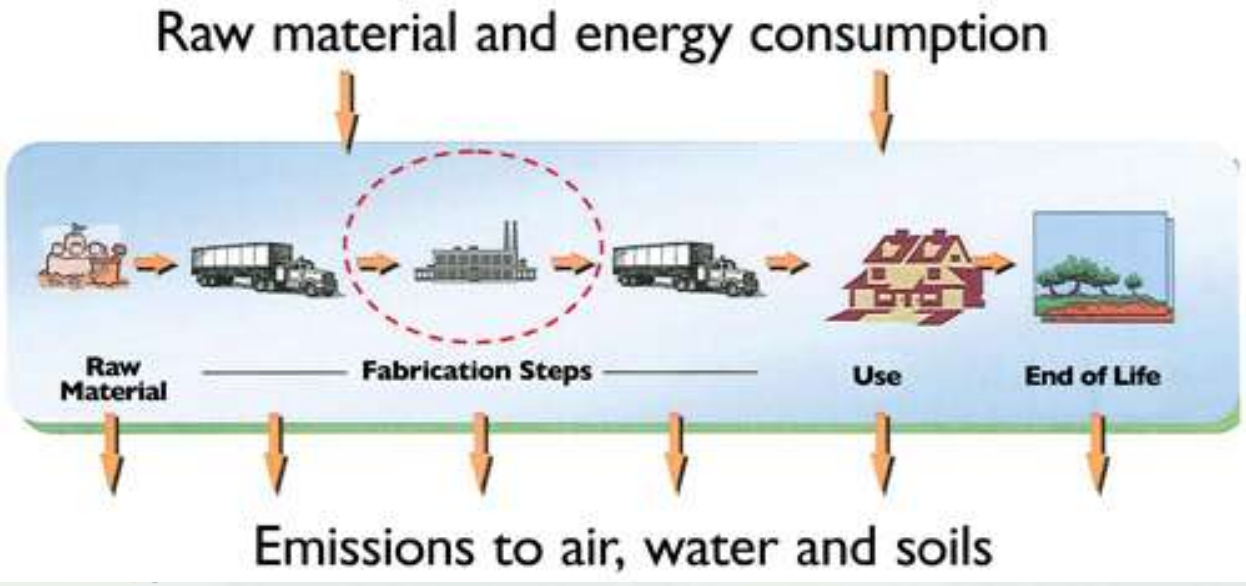
LCA Process Overview

1. Goal and Scope Definition
2. Inventory Analysis
3. Impact Assessment
4. Results and Interpretation

Definition
- Define goal and scope
- Collect data

Inventory
- Create/import flows
- Process inventory
- Implement characterisation factors

Results
- Choose LCIA method
- Compare alternatives
- Sensitivity analysis



LCA for Dredging in Long Island Sound

LCA Project Goal:

- Comparing dredged material disposal alternatives.

LCA Project Scope:

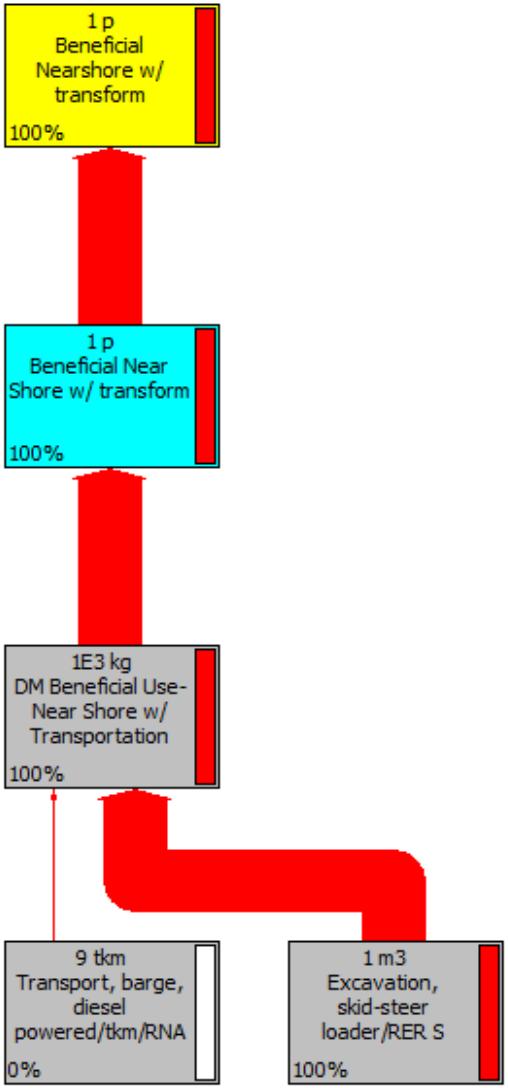
- System boundary: from just after DM is brought to surface until it reaches it final resting place.
- Functional unit: 100K cubic yards of sandy dredged material.
- 50 year maintenance period.
- Comparing open-water, upland, and island creation alternatives.

Assumptions

- Sediment is not contaminated.
- Process up until disposal is constant (i.e., all alternatives use similar bucket dredges).
- The land from the island creation will eventually become vegitated.

Long Island Sound, NY/CT

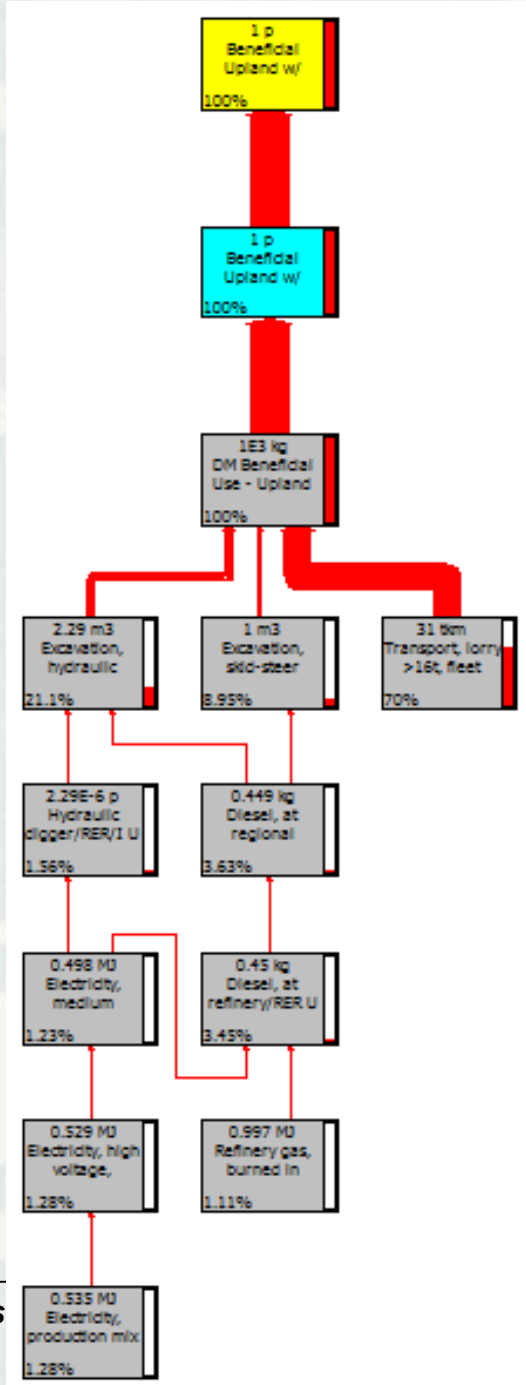
Process Inventories



Beneficial Uses

Near-shore BU, at left

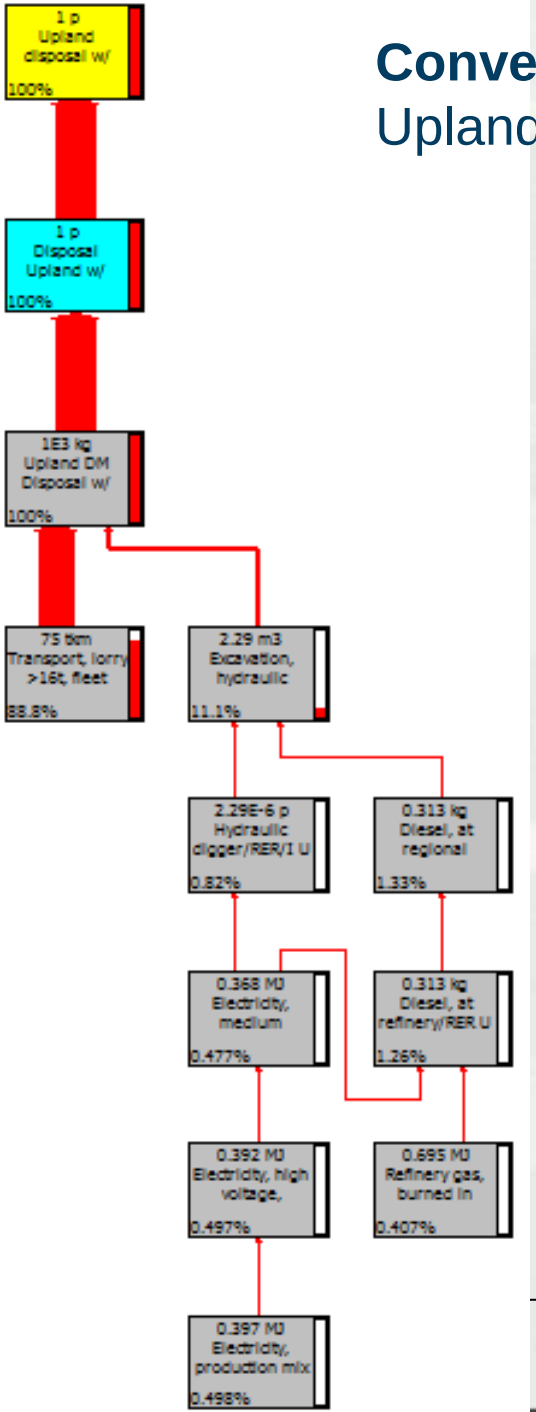
Upland BU, at right

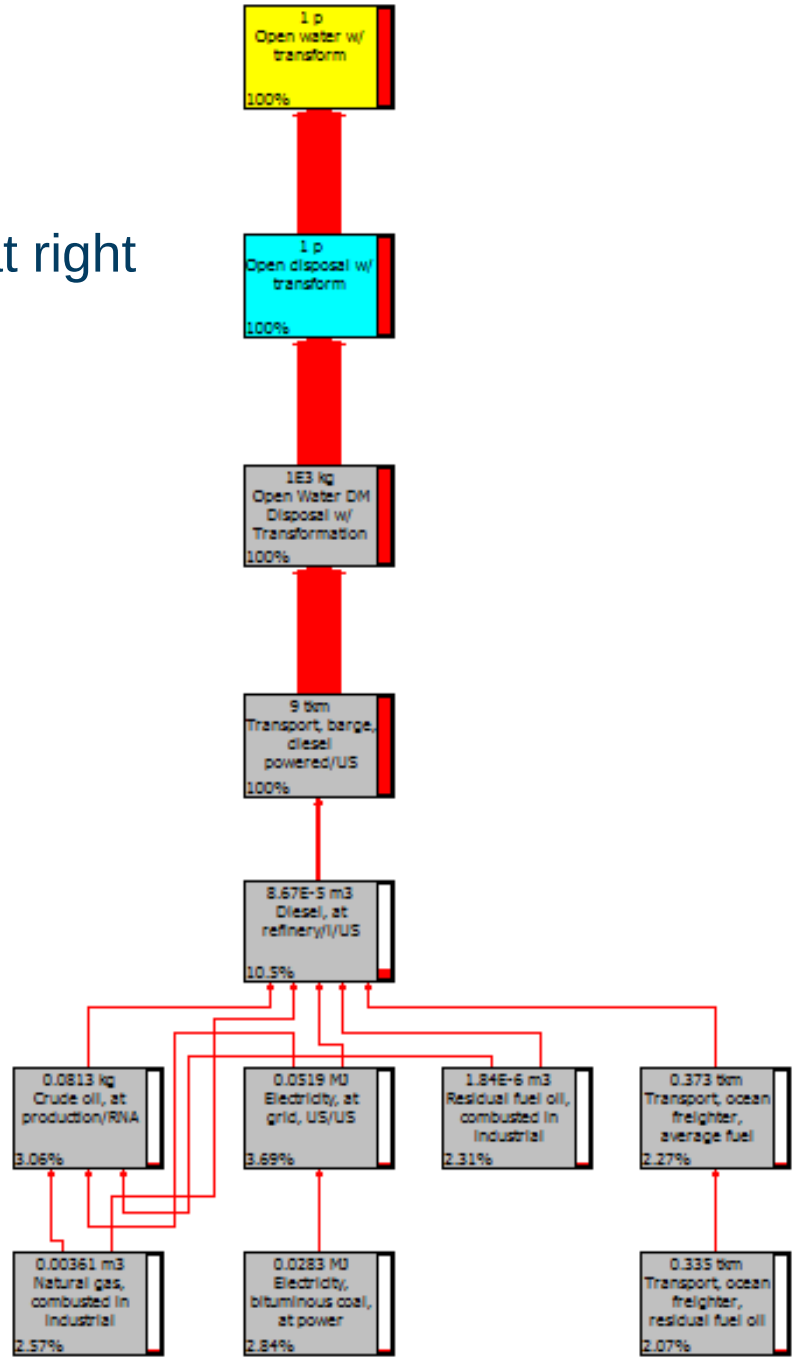


Conventional disposal

Upland disposal, at left

Open water, at right





Life-Cycle Inventory Details

- *SimaPro* software with *EcoInidicator 99* inventory assessment.
- *Hierarchist* weighting method (emphasizes land use and fossil fuels)

  Human health (40%), ecosystems (40%), resource use (20%).

Inputs

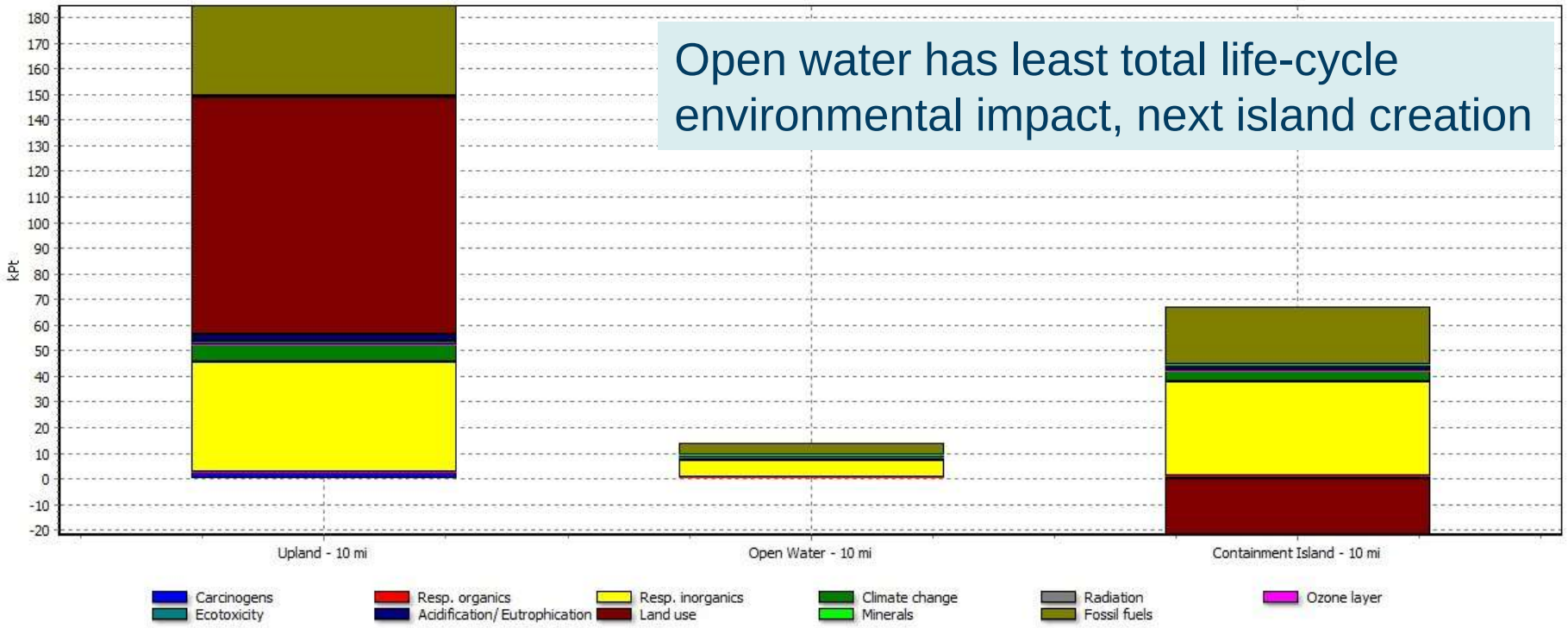
Flow	Category	Flow property	Amount	Unit	Sta
Aluminium, 24% in b...	Elemen...	Mass	5.24E-8	kg	
Anhydrite, in ground	Elemen...	Mass	3.26E-12	kg	
Barite, 15% in crude o...	Elemen...	Mass	2.85E-6	kg	
Basalt, in ground	Elemen...	Mass	9.17E-8	kg	
Borax, in ground	Elemen...	Mass	2.22E-10	kg	
Bromine, 0.0023% in ...	Elemen...	Mass	3.65E-13	kg	
Cadmium, 0.30% in s...	Elemen...	Mass	5.89E-11	kg	
Calcite, in ground	Elemen...	Mass	8.93E-6	kg	
Carbon dioxide, in air	Elemen...	Mass	2.15E-6	kg	
Carbon, in organic m...	Elemen...	Mass	5.8E-10	kg	
Chromium, 25.5% in ...	Elemen...	Mass	4.75E-8	kg	
Chrysotile, in ground	Elemen...	Mass	6.96E-12	kg	
Cinnabar, in ground	Elemen...	Mass	6.24E-13	kg	
clay occupation	Ztest	Volume	6.26E-4	m3	
Clay, bentonite, in gr...	Elemen...	Mass	3.19E-7	kg	
Clay, unspecified, in ...	Elemen...	Mass	2.08E-6	kg	

Characterization of claycontaminantrelease - ReCiPe En

LCIA category	Amount	Unit
ecosystem quality - agricultural land occupation	3.32E-8	points
ecosystem quality - climate change, ecosystems	1.47E-5	points
ecosystem quality - freshwater ecotoxicity	9.27E-10	points
ecosystem quality - freshwater eutrophication	1.42E-8	points
ecosystem quality - marine ecotoxicity	6.89E-6	points
ecosystem quality - natural land transformation	7.54E-6	points
ecosystem quality - terrestrial acidification	1.05E-7	points
ecosystem quality - terrestrial ecotoxicity	8.59E-8	points
ecosystem quality - total	2.26E-5	points
ecosystem quality - urban land occupation	1.18E-7	points
human health - climate change, human health	1.8E-5	points
human health - human toxicity	3.71E-5	points
human health - ionising radiation	8.05E-9	points
human health - ozone depletion	9.6E-9	points
human health - particulate matter formation	3.86E-6	points
human health - photochemical oxidant formation	2.12E-9	points
human health - total	5.89E-5	points
Marine Seabed occupation	1.06E-12	points
Marine seabed transformation	0	points
resources - fossil depletion	9.04E-5	points

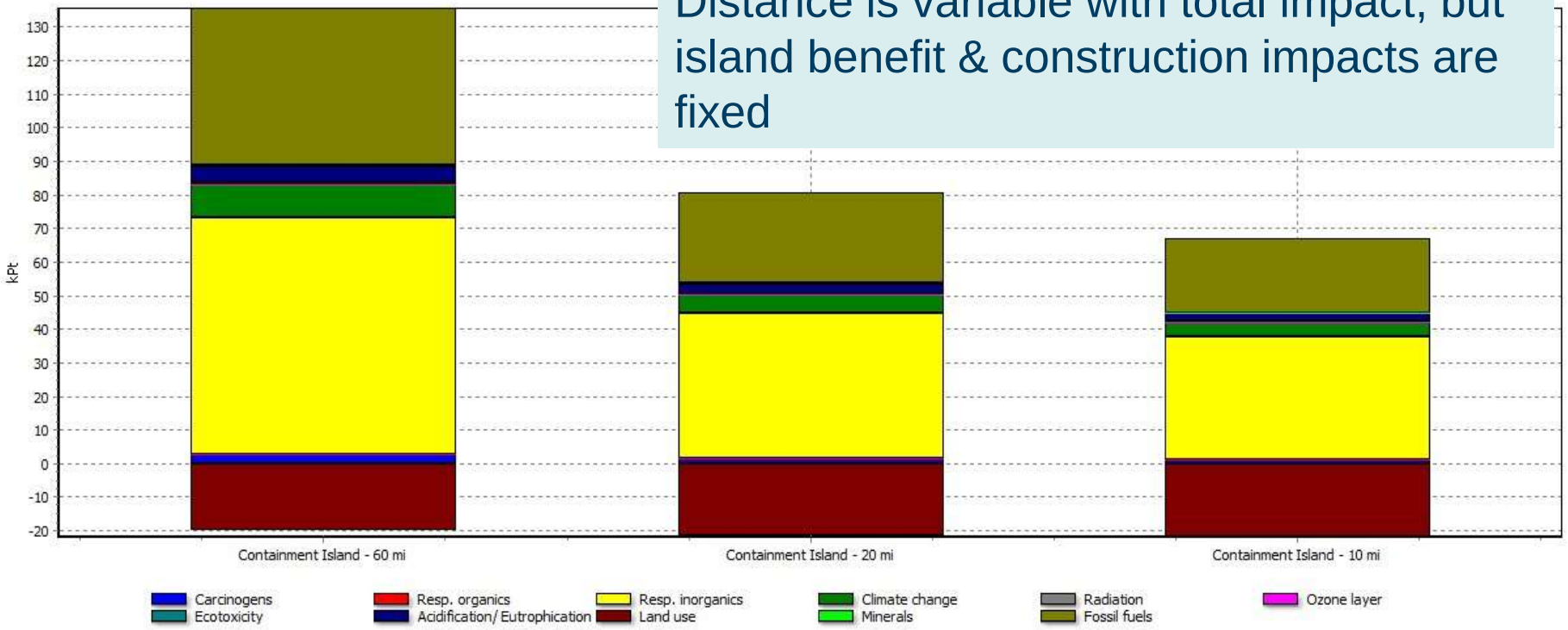
General information | Life cycle inventory | Characterization

Results:
Comparison Across Disposal Alternatives



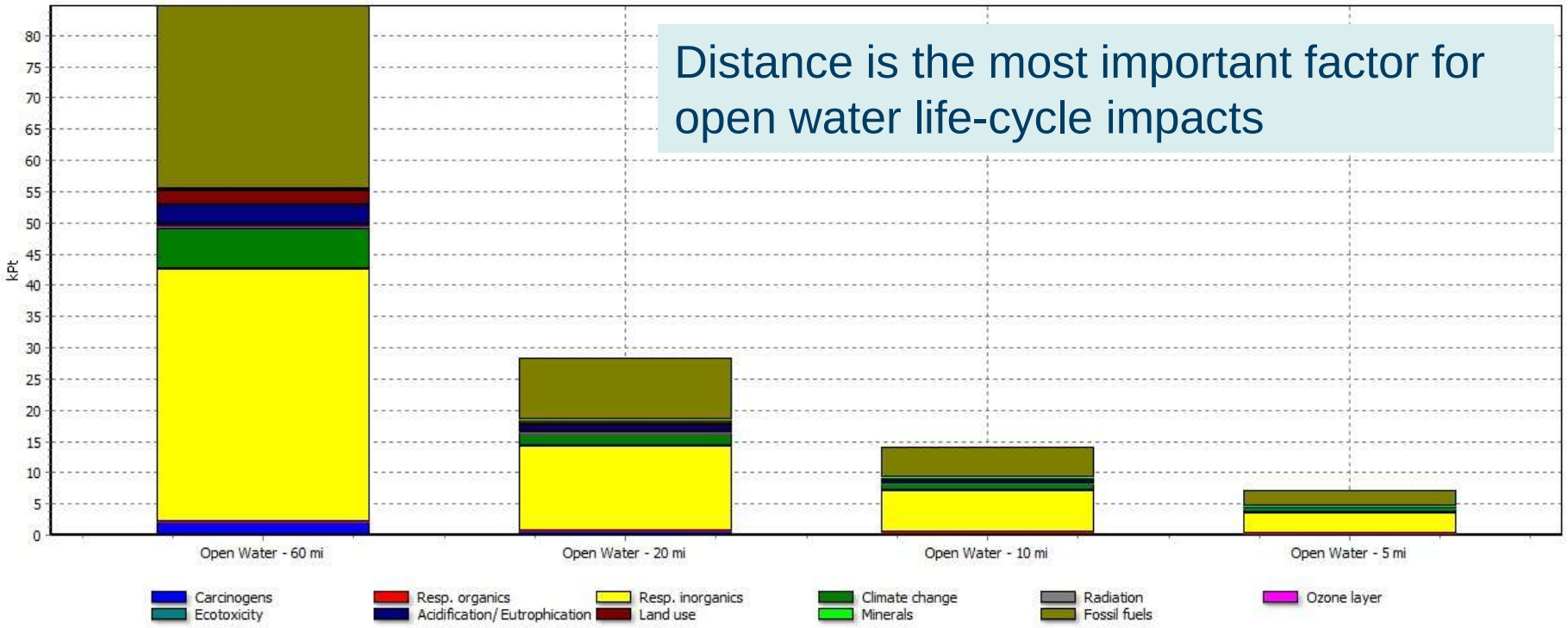
Results:
Impact of Distance on Island Creation

Distance is variable with total impact, but island benefit & construction impacts are fixed



Comparing 1 p 'Containment Island - 60 mi', 1 p 'Containment Island - 20 mi' and 1 p 'Containment Island - 10 mi';
Method: Eco-indicator 99 (H) V2.08 / Europe EI 99 H/A / Single score

Results:
Impact of Distance on Open Water Placement



Comparing 1 p 'Open Water - 60 mi', 1 p 'Open Water - 20 mi', 1 p 'Open Water - 10 mi' and 1 p 'Open Water - 5 mi';
Method: Eco-indicator 99 (H) V2.08 / Europe EI 99 H/A / Single score

Conclusions and Next Steps

- Useful for identifying and systematically considering long-term and distributed environmental impacts.
- A good source of inputs for D2M2 and other dredging decisions.
- Favors placement alternatives that involve lesser handling and transportation, or included beneficial uses.
- Can help in negotiating with agencies that want intensive solutions.

- Next Steps: Extend LCA inventories to include comparison of dredging.
- Merge LCA with Value of Information analysis to explore uncertainty.
- Help districts apply these techniques to negotiate with stakeholders or make progress towards Army sustainability goals.

3. Structured Stakeholder Interaction & Decision Analysis: Long Island Sound DMMP

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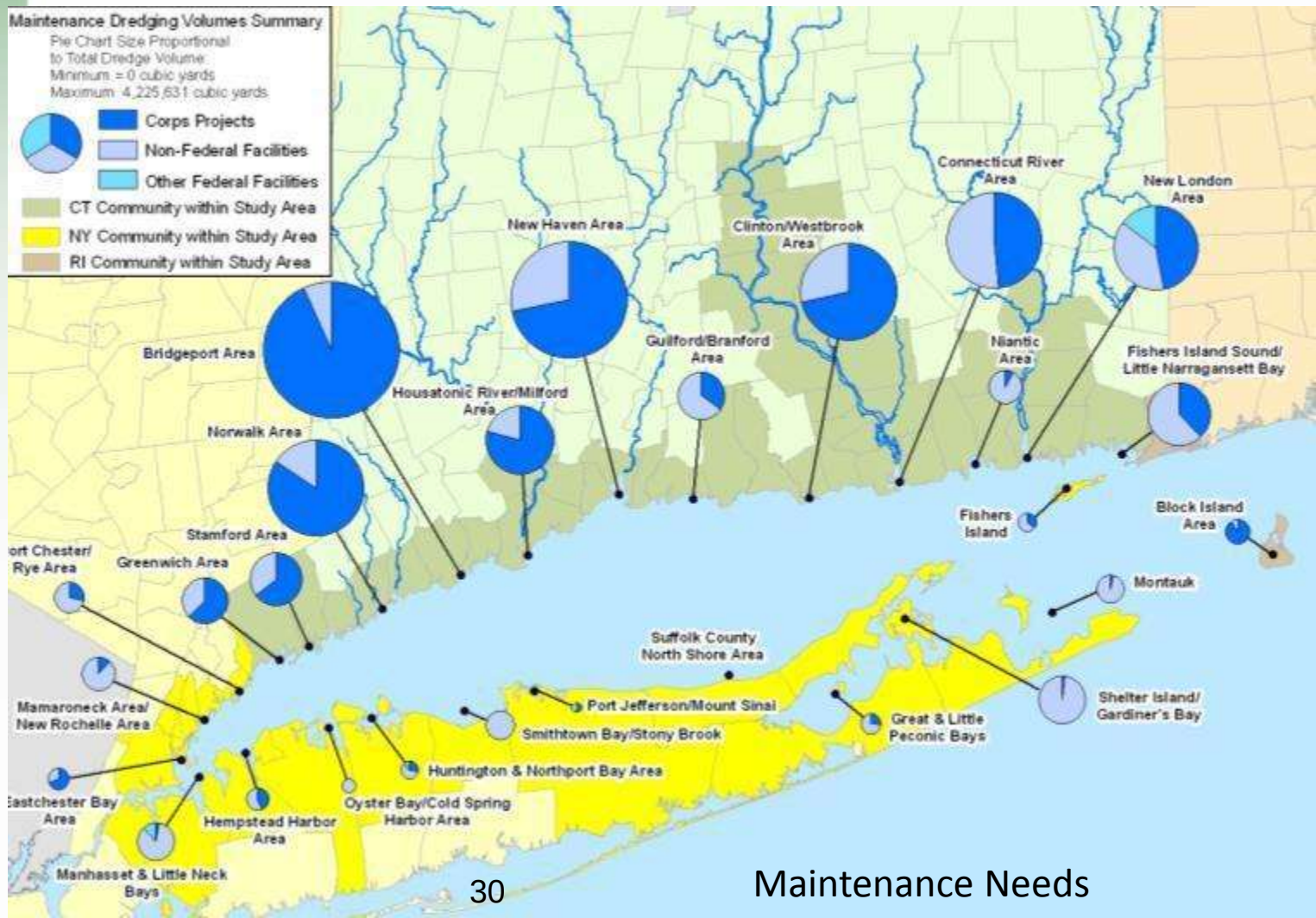
Long Island Sound study

- 38.5 million cubic yards of dredged material produced in 30 years
- Majority of combined needs from CT:
- New Haven
- ~8.7 million cy
- Bridgeport
- ~4.6 million cy
- New London
- ~2.5 million cy
- Connecticut River
- ~2.4 million cy
- Clinton/Westbrook
- ~2.4 million cy
- Norwalk
- ~2.2 million cy



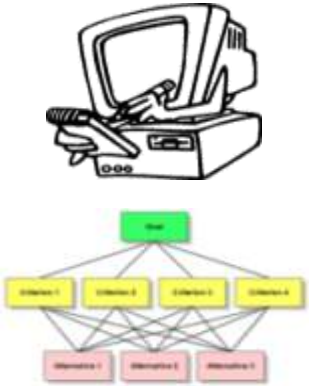
Maintenance Needs

Long Island Sound DMMP

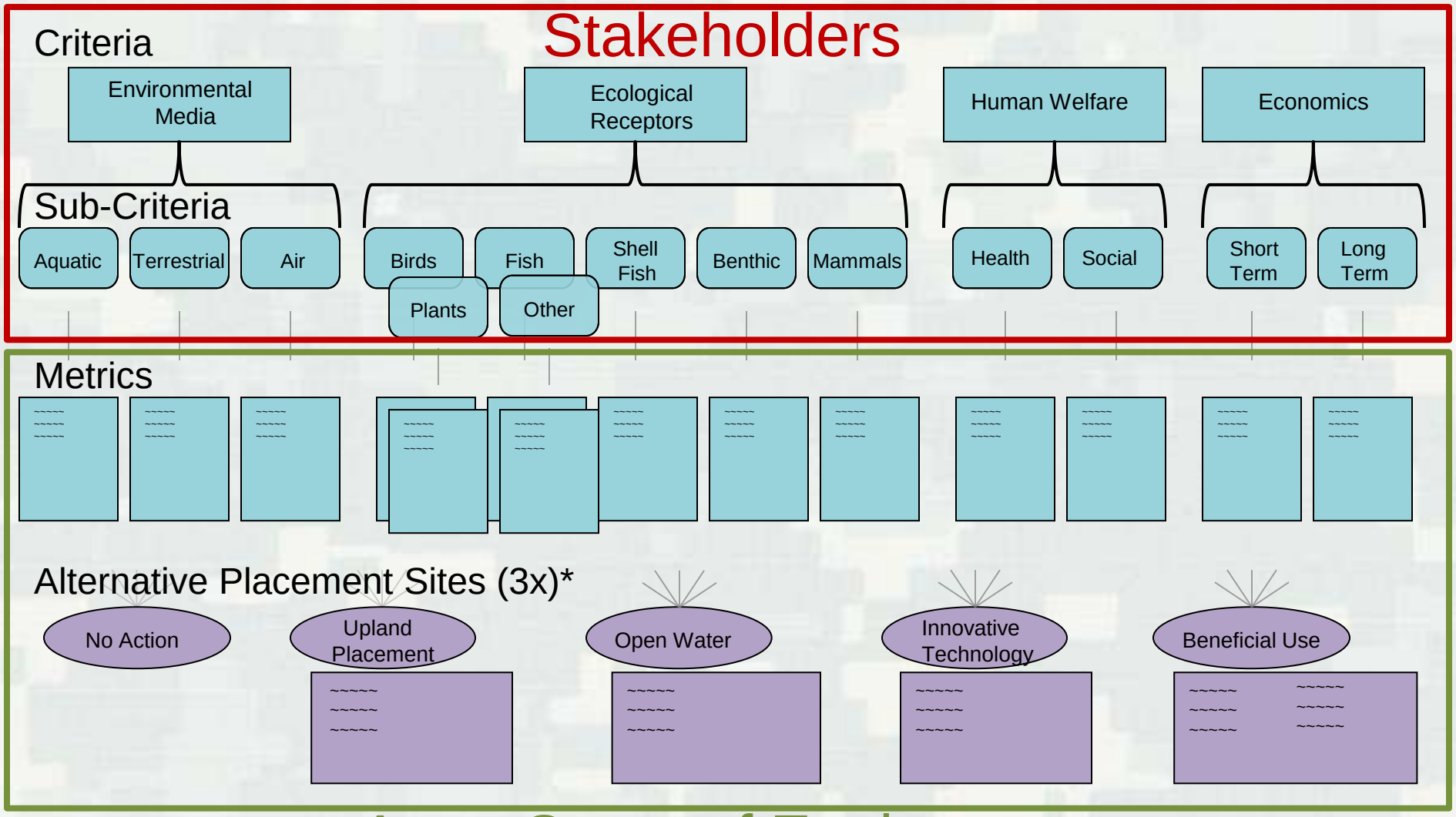
- DMMP requested by Governors of Connecticut and New York after the EPA designated changes to open water dredged-material disposal sites in LIS.
- Issue: Stakeholders disagree
  - States, Harbormasters, Marinas, Yacht Clubs, Boat Yards, Cargo Terminals, Power Plants, Military Facilities, State Piers, Ferry Terminals, Dredgers, etc.
- Result: $15M and 3 yrs later states & stakeholder issues reach US congress and process told to start over…

Stakeholder Engagement

- The process calls for Federal agencies to seek public input regarding development of the LIS DMMP.
- Earlier attempts at generating criteria focused on site-specific screening constraints; did not comprehensively address stakeholder values.
- The Corps has been hosting a series of Working Group meetings to established evaluation criteria based on stakeholder interests and concerns.
- A formal decision analysis will use input to rank alternatives.



Structure of the Decision Model



Army Corps of Engineers

Decision Model Process

- Individual stakeholder organizations "weight" the criteria and sub-criteria (which are defined by the metrics) to determine relative priorities and tradeoffs.
- District staff perform technical assessments to "score" the placement sites for each region of Long Island Sound against these metrics.
- Stakeholder weights and technical scores are combined through the MCDA model to rank the placement sites in each LIS region. Results will be reported as one component of the final LIS DMMP.

Thank You,

Any Questions?

Topics:
D2M2 Dredging Optimization
Life-Cycle Assessment for Sediment Disposal
Structured Stakeholder Interaction, LIS DMMP

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Outline

1. Background for dredging decision support
2. Geospatial multiobjective optimization
3. D2M2-J software
4. Future directions

Decision Support for Complex Environmental Problems

Human Health | Ecological Health | Remediation | Economics | Regulation | Values

Multi-Criteria Decision Analysis

Decision Input

MCDA Analysis Process